CONTOURING OF TITANIUM SPINAL RODS: FINITE ELEMENTS COMPARATIVE ANALYSIS OF DIFFERENT TECHNIQUES

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Introduction

The gold standard procedure to stabilize spinal deformities and severe imbalances requires the instrumentation with pedicle screws and rods.
Intra-operatively, rods are contoured to fit the physiological curvature of the spine by means of tools that perform permanent deformations (i.e. French bender).
This process could induce notches onto the surface and it is known to decrease fatigue performance of the rod[1,2].
Since an high failure rate related to rod bending is reported (about 8.6% which increase up to 15.8% when PSO is performed)[3], a numerical comparative study was performed to analyze different contouring techniques.

Methods

A finite element model of a spinal rod was developed and the elasto-plastic material mechanical properties were characterized through static tensile tests on several dogbone samples (Figure 1a).
Then different contouring techniques were simulated: particular attention was paid to compare the clinical procedure (French bender, Figure 1b) to methods which allow to obtain a more homogeneous curvature of the rods (Figure 1c).
Subsequently a four point bending was simulated; the same vertical displacement was imposed. The magnitude was determined in order to reflect physiological conditions.

Results

French bender induces at least 23% higher residual stresses with respect to homogeneous contouring technique; as a consequence, when these rods are subjected to the further four point bending the stress acting on them is increased. In addition when the contouring is performed through a French bender the plastic strain is localized, leading to a severe notching of the device.

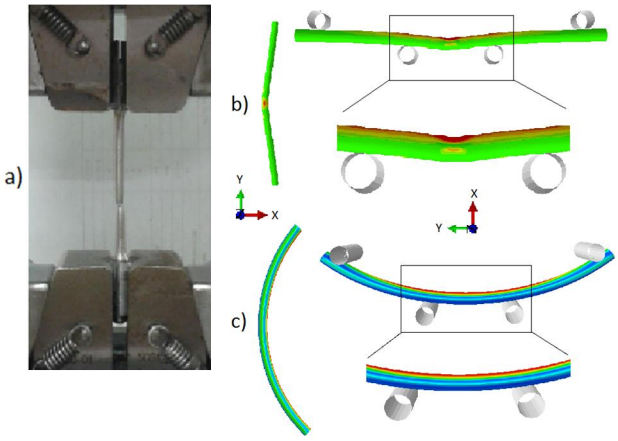

***Figure 1** a) Tensile test on dogbone sample; b) Clinical bending procedure; c) Homogeneous curvature*

Discussion

Rods are usually intra-operatively contoured by means of French benders; as result the stresses acting on the notched area may lead to fatigue failure.
On the other hand a more homogeneous curvature allows to reach the same angle of bend with lower residual stresses.
Therefore, the development of new contouring techniques, able to reduce high localized stress and to avoid notching of the surface, may increase the fatigue life of the rods.
Despite the numerical nature of the current study, the ongoing experimental fatigue tests will provide a further insight on the best bending technique.

References

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